THE AVIAN RESEARCH TASK FORCE

As noted above, KENETECH Windpower has been actively involved in the research of avian behavior around its Windplants since the mid-1980s. In many cases, the company has had tremendous success in reducing avian mortalities. Bird deaths, resulting from electrocution, have been significantly reduced within KENETECH's wind resource areas by retrofitting overhead electrical systems, utilizing underground wiring when feasible, and employing bird protection on all new installations.

The company has had limited success, however, determining why some birds (including certain types of raptors) are able to avoid colliding with wind turbines while other birds cannot.

In 1991, in the wake of the two-year study commissioned by the California Energy Commission, KENETECH sought the assistance of Dr. Tom J. Cade. At that time, Dr. Cade was Director of the World Center for the Birds of Prey and founding Chairman and Director of the Peregrine Fund, an organization committed to the study and preservation of raptors.

Accompanied by his colleague, Dr. William Burnham, President of the Peregrine Fund, Dr. Cade visited KENETECH Windpower's Windplants in the Altamont Pass and Solano County, California. They reviewed the research that was funded by KENETECH Windpower and the California Energy Commission's report. The initial observations of Drs. Cade and Burnham, later affirmed by the Avian Research Task Force, were as follows:

- Neither the KENETECH-commissioned research nor the study funded by the California Energy Commission was based on a sufficient number of observations to satisfy a scientific standard of verifiability. Windpower's blade painting research, for example, was not based on a statistically valid sample size to draw any conclusions regarding its viability as an effective mitigation device.

- To correct the methodological deficiency of previous studies, researchers must either increase the sample size or extend the time frame of the studies. (The reason that the number of observations in previous studies was so small is because relatively few natural encounters take place.) To address this problem, the time frame of the study could be shortened by artificially increasing the number of bird/turbine encounters through the use of trained bird populations.

- The number of recorded mortalities does not indicate *prima facie* that any of the affected populations are in danger in terms of population stability. To validate this assertion, a study should be undertaken to make a population estimate of Golden Eagles in the Altamont Pass and to calculate what proportion of Eagles observed in the Pass are migrants and which are residents.

Dr. Cade further suggested that individuals who have extensive research experience with avian physiological response to stimuli might be persuaded to design a study using trained birds. Based on his observations and recommendations, KENETECH asked Dr. Cade to assemble a task force of specialists to develop a comprehensive avian research program.

In August of 1992, the Avian Research Task Force was established to develop and implement a research program to devise effective long-term mitigation measures for KENETECH Windpower's Altamont Pass Windplant. The members of the Task force are:

- **Dr. Tom Cade**, Task Force Chairman and Professor *Emeritus* of Ornithology, Cornell University, Ithaca, New York. While working at the World Center for Birds of Prey and the Peregrine Fund, he pioneered adaptive breeding and reintroduction of the peregrine falcon in the wild, thus saving the species from extinction.

- **Dr. Mark Fuller**, National Biological Survey, U.S. Department of Interior and Director of the Raptor Research and Technical Assistance Center, Boise State University, Boise, Idaho. Dr. Fuller was formerly the chief of the Population Dynamics Group-Migratory Bird Research Branch at the U.S. Fish and Wildlife Service's Patuxent Wildlife Research Center in Patuxent, Maryland. Dr. Fuller was involved in the early use of radio telemetry in the study of avian flight and migration.

- **Dr. Melvin Kreithen**, Associate Professor, Department of Biological Sciences, University of Pittsburgh, Pittsburgh, Pennsylvania. Dr. Kreithen is a graduate of Cornell University and is the foremost authority on the sensory physiology of pigeons — involving the modalities of sight, sound and smell. Dr. Kreithen developed of the 3-D Tracking System being employed in the field research of the Task Force.

- **Dr. Vance Tucker**, Professor of Zoology, Duke University, Durham, North Carolina. A graduate of UCLA, Dr. Tucker is one of the world's foremost authorities on the gliding flight of birds, particularly vultures and eagles.

- **Dr. Charles Walcott**, Executive Director, Laboratory of Ornithology, Cornell University, Ithaca, New York. Dr. Walcott, a graduate of Harvard University, is an authority on the navigation of homing pigeons.

Two research facilities were established as focal points for the Avian Research program.

MIDWAY RESEARCH CENTER

The Midway Research Center is located, on-site, at the KENETECH Windpower Windplant in the Altamont Pass. KENETECH Windpower personnel are assisting with the Avian Task Force's research on a full-time basis: **Dr. David Schmitt**, the resident scientist responsible for managing and conducting the Altamont-based research projects; **Mr. Ron Barsic**, a pigeon handler and research technician; and **Ms. Denise Weingart**, a wildlife response coordinator and research technician. Dr. Kreithen is the research supervisor at this location.

BOISE RESEARCH CENTER

This facility is being developed and operated under a cooperative agreement between KENETECH and Boise State University (BSU) in Boise, Idaho. At this location, laboratory-based research is underway to better understand the sensory discrimination skills of raptors. The study team is utilizing the combined facilities of BSU, the Boise Zoo, and the Raptor Research and Technical Assistance Center. The Boise staff consists of **Dr. Hugh McIsaac**, the resident scientist; **Mr. George Carpenter**, a biological technician; and **Ms. Stephanie Gossett**, who provides administrative support. Drs. Cade and Fuller are the research supervisors at this site.

RESEARCH STRATEGY

The first question that the research must address is: *Why do some birds collide with the turbines while others do not?*

- Do birds collide with turbines because of some physiological problem or is it related to behavior?
- Can birds see the turbines and, if so, how do they perceive them?
- Do the rotating blades of a turbine appear to a bird as a disk or can a bird distinguish the rotation of individual blades?
- Are the birds that collide with turbines engaged in an activity or behavior that focuses their attention away from the turbines — i.e., in pursuit of prey or, perhaps, "riding" thermal wind currents and drifting backwards toward the turbines?
- Do the birds see the turbines but fail to perceive them as a threat?
- Are collisions a result of a combination of physiological and behavioral factors?
- Does the incidence of collisions vary by avian species?
- Are physiological and behavioral factors influenced by varying conditions such as the differences in lighting during the day?
- Is weather a factor in the collisions?
- Are wind speed and direction a significant factor in the collisions?
- Do certain turbine locations or alignments present more of a risk to birds than others?
- Is the size of a wind turbine blade and the rate of its rotation a relevant factor?

In order to answer these questions relating to avian sensory discrimination skills, the Task Force devised a research program to determine:

1. What birds can/cannot see and hear?
2. When, during the course of its flight, does a bird begin to take the mechanical action necessary to avoid a wind turbine?
3. Which colors and/or sounds do birds tend to avoid?

Through its research, the Task Force also hopes to gain a better understanding of how birds use the Altamont Pass wind energy production area (e.g., hunting, nesting, migration, etc.) in order to develop and implement effective long-term mitigation measures based on the natural behavioral traits of birds.

In order to determine what effect, if any, varying conditions have on a bird's ability to utilize its sensory perception skills, it is necessary to test and observe birds flying around the turbines at different times of the day and year, under a variety of weather conditions. Similarly, it is necessary to determine if these changes in conditions adversely affect avian activities around wind turbines.

The research of the Task Force also addresses an earlier problem — the inability to conduct tests and observations that produce statistically valid results. As previously noted, this lack of data has been a serious deficiency in every study done on this subject to date.

The Task Force research also focuses directly on the significance of avian mortalities in terms of broad population dynamics. The federal legal standard of protection for the Golden Eagle and many other species is "no losses". There is, however, a general consensus among experts familiar with this issue that this standard is not attainable. If this assertion is correct, the critical question is: *What level of loss* *is acceptable for each species?*

In order to understand the significance of the number of mortalities reported to date, it is necessary to understand the population dynamics of the species in question. For example, what is the significance of the loss of 78 Golden Eagles over a two-year period (if it actually were to occur)?

Finally, the Task Force's research strategy also addresses the need to validate the long-term effectiveness of any mitigation action and/or device it proposes to KENETECH Windpower.

RESEARCH PROGRAM COMPONENTS

1. Controlled Flight Experiments with Pigeons and Measured Observations of Wild Bird Flight Activity

The opportunity to observe wild bird activity around wind turbines is limited by the number of encounters that naturally occur. In order to accumulate enough data to make valid observations, the Task Force elected to augment the observations of wild bird behavior in the Altamont Pass with flights of captive birds.

The objective of this research is to determine how various factors, such as a wind turbine or a string of turbines, affect the maneuverability and collision avoidance capabilities of powered or flapping flight (as well as other activities) of birds.

To carry out this research, two homing pigeon lofts have been established: one loft is located within the Altamont Pass Windplant; the other is located on the periphery of the Pass. Because the homing pigeons will return to their home loft, the utilization of these birds enables the researchers to make several hundred observations of flight behavior a week. In such flights, the homing pigeons quickly establish the direction they must take to return to their loft, making it easy to plan a release that requires the pigeons to maneuver around at least one set of turbines (usually at the release site) while enroute.

In these field tests, individual pigeons are released at various locations under a variety of conditions. Their behavior is observed and recorded visually and by the 3-D mechanical tracking device designed by Dr. Kreithen. Factors and conditions which are being tested include wind direction and velocity, lighting and range visibility, terrain, turbine type and array, and the operational status of the turbines during the test period.

In addition, field researchers will take every opportunity to observe and record the kiting (riding the wind currents) and diving flight activities of the raptors. Data from flights made under similar conditions and terrain, in areas that do not contain wind turbines, will be compiled for comparison purposes.

The findings of this research, coupled with the information obtained in Boise regarding raptor visual and auditory stimuli, will result in a series of controlled raptor flights to test the effectiveness, in terms of altered flight behavior, that occurs when the visual and/or auditory profile of a wind turbine is altered.

A critical element of flight observations is the development and utilization of the 3-D tracking system. The Task Force will be flying birds and observing natural behavior under a variety of conditions to determine what effect, if any, these factors have on the flight paths of birds maneuvering around wind turbines. The tracking system integrates several pieces of information simultaneously, enabling researchers to measure any variations in avian flight behavior.

In controlled flight situations, birds are released at scheduled intervals. The birds are then tracked by a researcher, using a siting device (similar to a telescopic sight on a rifle) which is mounted on a laser-based range finder. This tracking device is coaxially mounted on a bracket with a video camera. The bracket rests on a tripod to facilitate operation.

The system simultaneously calculates height, azimuth (direction) and distance, thus establishing a bird's location in space in relation to the turbines and the ground along the course of its flight path. With the tracking device, the Task Force can accurately trace the flight of homing pigeons around turbines and document the point at which a bird visibly reacts to the structure. During the course of experiments with controlled birds, any activity of wild birds will also be observed and recorded by the 3-D tracking system.

The tracking system is perhaps the most important means the Task Force will employ to demonstrate the effectiveness of a specific form of treatment as a mitigation measure. After compiling a database of behavior under various conditions, the Task Force will be able to quantify the differences in flight patterns, if any, that are produced by specific mitigation measures employed on or around the wind turbines.

2. SENSORY PHYSIOLOGY OF RAPTORS

In order to test the validity of employing color, patterns, shapes and/or sound as a means of alerting birds to the presence of turbines or otherwise altering their behavior, the Task Force designed a series of non-invasive experiments with raptors to establish what these birds can see or hear.

Over the years, naturalists have observed that certain colors and patterns appear to be an effective defense in startling and deflecting potential predators of a specific species. The American Kestrel, for example, has "eye spots" and a facial pattern in the plumage on the back of its head. This feature may function to ward off potential predators, or robbers of its food, that approach the Kestrel from the rear. Many predatory birds are apparently reluctant to fly directly into the face of an enemy: the "eyes" seem to be the main signal involved in this deterrence.

Three types of raptors — American Kestrels, Red-tailed Hawks, and Golden Eagles — are being studied in a laboratory setting at the Raptor Research Center in Boise, Idaho, to determine their ability to recognize wind turbines, turbine blade rotation, and the leading edge of a turbine blade. These studies will also determine which colors, patterns, and sounds are detectable to the birds and which of these produce the strongest reactions. The protocol (test procedure) for this type of experimentation is well established, having been used extensively for research on pigeons.

Data from these experiments will be used to devise field tests which will use flight situations to determine what visual or auditory stimuli can most effectively extend the range in which a bird can recognize a wind turbine as an obstacle and take evasive action.

This research effort is integrated with the controlled flight experiments taking place in the Altamont Pass. As behavioral observations are made in the field, they will be shared with Task Force researchers working on sensory discrimination in the lab in Boise.

Early research on pigeons demonstrated their ability to distinguish rotating lines. The Task Force's recent field observations of pigeon avoidance behavior around wind turbines strongly suggests that the birds are able to distinguish the rotation of individual turbine blades. Based on these observations, lab experiments will be devised to determine whether raptors are also capable of seeing rotating turbines blades in a similar fashion.

Conversely, if the sensory physiology experiments find that a particular color or pattern or sound appears to have the potential of alerting a raptor to the presence of a turbine, thereby enhancing a bird's avoidance skills, the field tests can be devised to determine the effectiveness of employing that color pattern or sound as a mitigation device in a Windplant.

It is anticipated that this type of integrated testing will begin in the Spring of 1994.

3. MORTALITY SEARCHES

At present, KENETECH Windpower field personnel are trained to spot and report any avian injury or mortality to Ms. Weingart, the wildlife response coordinator. Incident reports and any other historical data is under review by the Task Force in an effort to glean information that might suggest the cause and circumstances surrounding a bird mortality or injury.

Mortality searches, or carcass surveys, are being conducted around the Model 33M-VS turbines and a paired, or control, group of Model 56-100 turbines in the same vicinity.

This phase of research is designed, in part, to address an assertion by a few representatives of the Fish and Wildlife Service. They believe that KENETECH Windpower's new advanced wind turbine, the Model 33M-VS, presents an increased hazard to birds flying in the Altamont Pass because of its large rotor sweep area (33 meters).

The Model 33M-VS is a utility-grade wind turbine that generates electricity at rates competitive with conventional power generating fuels. The overwhelming majority of KENETECH Windpower wind turbines operating in the Altamont Pass are an earlier generation of turbines, the Model 56-100. The rotor sweep of the Model 56-100 is 59 feet.

ADDITIONAL RESEARCH

REGIONAL EAGLE POPULATION STUDY

The Fish and Wildlife Service has two distinct and often contradictory missions. The Law Enforcement division is charged with enforcing laws that are aimed at protecting individuals within a species such as the Migratory Bird Treaty Act, the Endangered Species Act, and the Bald Eagle Protection Act. The agency's other mission is to focus on population and habitat preservation, and to develop regulations that protect the vitality of a specific population.

It is unlikely that KENETECH Windpower will be able to totally eliminate the risk of avian mortalities related to wind energy production. Therefore, it is necessary to determine the amount of losses which can be sustained without jeopardizing the ability of specific species to maintain viable populations.

On September 1 and 2 of this year, KENETECH Windpower convened a conference of raptor experts which included representatives of the Fish and Wildlife Service and the Department of Fish and Game. The purpose of the gathering was to design a study program to determine the size and reproductive rate of Golden Eagles residing in the vicinity of the Altamont Pass and Solano County, California wind resource areas.

The conference participants recommended a study in which Golden Eagles will be banded and equipped with wing (patagial) tags and/or radio transmitters. A telemetry system was recommended to facilitate the ground tracking of the birds which will, in turn, enable researchers to determine the range of the age classes of resident eagles, the time eagles spend in various locales, and the type of activity occurring within these locations. It is hoped that funding support will be obtained in order to begin work in late 1993.

COLLISION IMPACT DETECTION SYSTEM

For well over a decade, KENETECH Windpower has been operating wind turbines in the Altamont Pass. Construction and maintenance personnel are on-site on a daily basis. In addition, since 1988, wildlife studies have been conducted in KENETECH's Windplants. However, it was not until August of 1993 that a bird was observed being accidently struck by a wind turbine during a pigeon flight. In an effort to capture more of these events and particularly those involving wild birds, an impact detection system is being designed for testing this Fall.

A four-camera integrated video monitoring system will be installed at a location where multiple bird-turbine collisions have occurred. These cameras will operate from dawn to dusk. The video tapes will be randomly sampled at regular intervals. If, however, a carcass is found in an area around one of the wind turbines monitored by the video camera, those tapes will be fully reviewed to see if the event was captured.

A key part of this study will involve positioning the four cameras to determine how best to capture the critical field of view. Personal observations will also be conducted as part of this study and used to compare the effectiveness of remote tracking to that of personal observations.

Given the infrequency of bird-turbine collisions and the thousands of wind turbines in the Altamont Pass, the likelihood of recording an impact is very low. Capturing a collision on video tape could enable the Task Force to fill critical gaps in its information base and possibly accelerate the timetable for making effective mitigation recommendations.

This project is an initiative of the Electric Power Research Institute (EPRI) and will be funded by EPRI and the U.S. Department of Energy (DOE) with KENETECH Windpower providing coordinating support.

SUMMARY

The research effort mounted by the Avian Research Task Force and funded by KENETECH Windpower, combined with the level of talent being marshaled to conduct the program is extraordinary. The Task Force is at a stage of testing research designs and developing equipment and field-testing procedures. Data generation is ongoing with the pace of the research expected to quicken exponentially.

A considerable effort is being made to share each step of the avian research process with interested and active parties such as environmental organizations and government agencies. This cooperative effort will ensure that the "right questions" are being asked to guarantee the objectivity and integrity of the process, of the data gathered by the Task Force, and of any mitigation measures it may recommend.

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REVIEW OF AVIAN MORTALITY DUE TO COLLISIONS WITH MANMADE STRUCTURES

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INTRODUCTION

Birds have undoubtedly been colliding with manmade structures ever since humans started building things skyward. The earliest documented instances of collision mortality in this country are from the late 1800's (Coues 1876, Merriam 1885) and the problems continue unabated today. The total avian mortality due to collisions with manmade obstacles is probably greater every year as buildings, towers, chimneys, overhead power lines, and other structures are erected in ever-increasing numbers. Weir (1976) provides an excellent review of bird migration, weather, and collision mortality associated with various types of structures.

The biological significance of collision mortality to any species is unknown. There are too many other factors, such as total population size, natural mortality levels, and other human related influences, for which insufficient data exist to be able to put the collision mortality factor in proper perspective. Recognizing these limitations, Banks (1979) recently analyzed avian mortality, including collisions, related to human activities and estimated that about 4.75 million (0.05%) of the 10 billion annual bird deaths result from collisions with manmade structures.

In this paper, I will discuss each of the major sources of avian collision mortality and briefly review any pertinent investigations recently completed, currently in progress, or planned for the near future. Where relevant, comparisons with mortality estimates of Banks (1979) and others will be made. In addition, measures that have been developed to reduce the amount of various types of collision mortality will be mentioned.

Basically, this is a review, and the information presented herein was obtained from the published literature and through personal communications with investigators in this field. Most of the available reports and articles were previously compiled in an annotated bibliography (Avery et al. 1978a). For some of the mortality categories, certain analyses were made to obtain an indication of the magnitude of the annual losses attributable to these sources. These analyses are described in the appropriate sections of the discussion.

DISCUSSION OF MORTALITY SOURCES

TV and Radio Towers

Since the mid 1950's, bird losses at TV and radio towers have attracted much attention, especially throughout the Eastern United States. These structures and their supporting guy wires comprise the largest single category among the available reports and articles dealing with collision mortality (Avery et al. 1978a). The annual losses due to collisions with towers have been estimated at 1.0 to 1.25 million birds (Aldrich et al. 1966, Banks 1979) which represents approximately 0.013 to 0.016 percent of the total estimated annual avian mortality (Mayfield 1967, Banks 1979).

Because mortality can vary considerably from year to year, in deriving my own estimate of the yearly number of tower-killed birds, I considered only studies of at least 10 years' duration. Just four studies meet this criterion; three of these report fall mortality only, so I restricted the analysis to fall losses. Table 1 summarizes the fall mortality data at the four locations; each tower has been under investigation for at least 11 years. The wide range in fall mortality figures underscores the necessity for long-term investigations. On a per tower basis, WCTV at Tallahassee has recorded the highest seasonal mortality (1305), followed closely by WSGN at Nashville (1155). The lowest seasonal mean is from WIVB in Buffalo (61).

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Second, the U.S. Fish and Wildlife Service (FWS) is currently involved in three projects in the Upper Midwest. At Red Wing, Minnesota, the Service, in cooperation with Northern States Power Company, is investigating the effects of a proposed 345 kV power line crossing the Mississippi River. Preconstruction studies include radar monitoring of bird movements through the area and laser beam simulation of a power line to determine the potential bird strike incidence. Postconstruction efforts will concentrate on assessments of bird mortality at the line. In North Dakota, the FWS area office at Bismarck initiated a post card survey and questionnaire on bird strikes at overhead wires to identify specific problem areas in the state. The survey elicited 37 responses concerning 66 losses in 1978, and the survey will continue at least through 1979 (Cernohous 1978). The Northern Prairie Wildlife Research Center (FWS) in Jamestown, North Dakota, in cooperation with several utility companies, has designed a study to determine the magnitude and significance of bird strike mortality to avian populations. This study, which has not yet commenced, will concentrate first on known trouble spots, and then expand to other areas in the state if the level of mortality indicates a second phase is warranted. The mortality due to collisions with wires will be evaluated in the context of other, documented mortality factors such as disease, predation, and hunting.

Finally, the Electric Power Research Institute, Palo Alto, California, has contracted for a multi-year study of bird flight interactions with overhead transmission lines. The initial phase of the study, expected to begin in January 1980, will be concerned with the development of techniques and procedures for data collection and analysis of bird interactions with transmission lines.

These and, hopefully, other studies will ultimately provide answers to the questions concerning the magnitude and biological importance of bird losses at overhead lines, and will provide necessary direction for reducing the problem.

CONCLUSION

From this review, it is apparent that the primary source of collision mortality among birds are not the spectacular, episodic events recorded at stuctures such as TV towers and power plant stacks, but are the small, incremental losses associated with the millions of kilometers of power and communication lines and the billions of glass windows throughout the country. Losses from the latter two sources are difficult to document because mortality at any one site is usually so small it goes unnoticed. However, windows and overhead wires, together with road-related losses (Banks 1979), may account for hundreds of millions of bird deaths annually. Whether or not such mortality is of any biological significance remains to be determined, but in view of the deleterious effects of pollution, habitat destruction, and other human-related activities, the impacts of collision mortality cannot be ignored.

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Table 1 Fall tower kill data from four tv towers in the eastern United States

	Tallahassee[1]	Nashville[2]		Buffalo[3]			Elmira[4]
	WCTV	WSM	WSIX	WGR	WKBW	WIVB	WSYE
Tower height above ground (m)	308	415	285	291	326	321	255
Fall seasons monitored	21	16	20	11	12	12	14
Number of birds collected	[illegible]	18568	6224	5389	4117	726	8771
Mean fall kill	1305	1161	311	490	360	61	627
Range	[illegible]	56 3603	56 1553	24 1824	16 1312	1 190	45 3874

[1] Crawford 1974 1978

[2] Laskey 1956 1957 1960 1962 1963a 1963b 1964 1965 1966 1968 1969a 1969b 1971, Gamer 1962 Bierly 1973, Goodpasture 1974a, 1974b, 1975, 1976

[3] A R Clark Buffalo Museum of Science Buffalo N Y Personal communication

[4] Howard 1963, 1966, 1967, 1968, 1969, 1970, 1971, 1972, 1973, 1974, 1977, Kibbe 1976

Table 1 Fall tower kill data from four locations in the eastern United States

	Tallahassee	Nashville[2]		Buffalo[3]			Elmira[4]
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Mean fall kill	1105	1161	311	490	360	61	627
Range	216 3421	56 3683	56 1553	24 1824	16 1312	1 190	45 3874

[1]Crawford 1974, 1978
[2]Laskey 1956, 1957, 1960, 1962, 1963a, 1963b, 1964, 1965, 1966, 1968, 1969a, 1969b, 1971, Ganier 1962, Bierly 1973, Goodpasture 1974a, 1974b, 1975, 1976
[3]A.R. Clark, Buffalo Museum of Science, Buffalo, N.Y. Personal communication
[4]Howard 1963, 1966, 1967, 1968, 1969, 1970, 1971, 1972, 1973, 1974, 1977, Kibbe 1976

Table 2 Rates of bird loss due to collisions with power lines

Location	Number of dead birds collected	Wire km	Study period	Losses/wire km/yr
Denmark[1]	105	432.3	19 da (0.5 yr)	0.49
Oregon/Washington[2]				
Lower Crab Creek	12	13.2	6 mo (1 yr)	0.91
Frenchman Hills	2	8.8	3 mo (0.5 yr)	0.45
Rocky Ford Creek	0	19.6	3 mo (0.5 yr)	0
Bybee Lake	76	14.0	9 mo (1.5 yr)	3.62
Riekkola	1	2.4	3 mo (0.5 yr)	0.83
Bear River	0	2.4	3 mo (0.5 yr)	0
North Dakota				
Snake Creek[3]	632	50.4	24 mo (5 yr)	2.51
Underwood A[4]	49	25.8	6 mo (1.5 yr)	1.27
Underwood B[4]	51	43.5	4 mo (1 yr)	1.17

[1]Andersen Harild and Bloch (1973)
[2]Lee (1978), Meyer (1978)
[3]McKenna and Allard (1976), McGlauchlin (1977), Cernohous (1978)
[4]Cassel et al. (1979)

Collision Course:
The Hazards of Lighted Structures and Windows to Migrating Birds

A Special Report by Lesley J. Evans Ogden for World Wildlife Fund Canada
and the Fatal Light Awareness Program, September 1996

APPENDIX 1, Bird Collision Literature Summary Table
(TV Tower Collisions)

Locations	Years	No. Killed	No. Species	Predominant Species/Groups	Reference *
WJBF-TV, Aiken, SC, USA	1962	400	32	Red eyed Vireo	766
Alleman, Iowa, USA	1972	726		406 (40%) Warbler	420
Baltimore, MD, USA	1964	1032	37	300 (29%) Ovenbird	669
Barrie, ON, CAN	1974	4900		1000 (20%) Bay-breasted Warbler, 900 (18%) Ovenbird	337
Boston, MA, USA	1958	**300**		Warbler, Vireo	63
Boyleston, MA, USA	1971	158	29	134 (85%) Warbler, 95 (60%) Blackpoll Warbler	62
Boylston, MA, USA	1970	350	29	266 (76%) Warbler	61
Buffalo, NY, USA	1978	359	51	44 (15%) Blackpoll Warbler, 36 (10%) Ovenbird, 35 (10%) Swainson's Thrush, 25 (7%) Red-eyed Vireo	892
Buffalo, NY, USA	1974	651		Warbler	169
Buffalo, NY, USA	1970	534	46	105 (20%) Yellow-rumped Warbler, 63 (12%) Black-throated Blue Warbler	775
Carolinas, USA	1962	4189	61	American Redstart, Ovenbird, Vireo	5
Cedar Rapids, IA, USA	1963			Thrush, Warbler	585
Chapel Hill, NC, USA	1956	**2500**	**40**	Warbler, Thrush	Chat (1957) Mar
Chapel Hill, NC, USA	1956	**2500**		Warbler	159
Charleston, NC, USA	1954	1000-E18	**24**	Warbler, Common Yellowthroat	Chat (1954) 18(4)
Charleston, SC, USA	1962			Red-eyed Vireo, Ovenbird, American Redstart	766
CHRE-TV, Regina, SK, CAN	1965	172		Warbler	90
CKCK-TV, Regina, SK, CAN	1965	227		Warbler	90
CKVR-TV, Barrie, ON, CAN	1975	175		Bay-breasted Warbler, Ovenbird, 414 (10%) Red-eyed Vireo, 313 (8%) Chestnut-sided Warbler	840
Columbia, MN, USA	1963	941		Red-eyed Vireo, Ovenbird	585
Dallas TX, USA	1960	11	1	Yellow Rail	85
Davenport, IA, USA	1960	281	25	Thrush, Warbler	506
Dayton, OH, USA	1966	305	49	Red-eyed Vireo, Golden-crowned Kinglet, Ovenbird	590
Des Moines, IA, USA	1974	1500		750 (50%) Red-eyed Vireo	415
WEAU-TV, Eau Clair, WI, USA	1957	1525	40	Warbler	404
WEAU-TV, Eau Clair, WI, USA	1957	2972	42	Warbler	116
Elmira, NY, USA	1966	270		Ovenbird	644
Elmira, NY, USA	1969	300		Bay-breasted Warbler	647
Elmira, NY, USA	1972	**540**	55	Warbler	649
Elmira, NY, USA	1975	800	40	198 (25%) Bay-breasted Warbler, 78 (9.8%) Ovenbird, 110 (14%) Magnolia Warbler	411

Erie County, NY, USA	1977	1397	50	168 (12%) Bay-breasted Warbler, 154 (11%) Ovenbird, 112 (8%) Magnolia Warbler	172
FL, USA	1964	4707	37	4646 (99%) Warbler	154
FL, USA	1971	2500	42	Warbler	394
FL, USA	1972	1347	49	1199 (89%) Warbler	744
Grand Bahama Is, USA	1966	136	22	Gray-cheeked Thrush, Blackpoll Warbler	401
Jacksonville, FL, USA	1964	**2000**		1900 (95%) Warbler, 273 (14%) Blackpoll Warbler	193
Jacksonville, USA	1970	146		Warbler	633
Jacksonville, USA	1967	174		Ovenbird	635
KCMO-TV, KS, MO, USA	1975	67		23 (34%) Mourning Dove	289
KOMU-TV, Columbia, MO, USA	1954	1887	63	354 (19%) Common Yellowthroats, 313 (17%) Gray Catbird	290
KROC-TV, Ostrander, MN, USA	1961-62, 1972-74	3507	84	619 (18%) Northern Waterthrush, 516(15%) Red-eyed Vireo	729
KTOL-TV, Coweta, OK, USA	1974	117	28	64 (55%) Nashville Warbler	554
Lawrence, KS, USA	1969	19		Thrush and Sparrow	545
Lennox Power Plant, Barrie, London TV ON, CAN	1974	7550		1359 (18%) Bay-breasted Warbler, 1129 (15%) Red-eyed Vireo, 1038 (14%) Ovenbird, 920 (12%) Magnolia Warbler	283
London, ON, CAN	1970			Ovenbird, Warbler	279
Madison, WI, USA	1968	**493**	33	Thrush, Warbler, Warbler	677
Maryville, MO, USA	1972	71	33	Sparrow	69
MI, USA	1954	230		Blackpoll Warbler	224
Moosejaw, SK, CAN	1959	33	13	Yellow-rumped Warbler, Orange-crowned Warbler	426
NY, USA	1959	110		Warbler, Vireo	663
Olney, IL, USA	1978	622	36	498 (80%) Warbler	351
Omega Tower, LaMoure, ND, USA	1973	**1417**	51	Finch	38
Omega Tower, LaMoure, ND, USA	1972	255	58	Finch	39
Omega Tower, LaMoure, ND, USA	1972	226	66	Warbler	39
Omega Tower, LaMoure, ND, USA	1971-73	937	102	Warbler, Vireo	42
Omega Tower, LaMoure, ND, USA	1971	152	41	Warbler, Vireo	25
ON, CAN	1961	**1115**	57	156 (14%) Ovenbird, 99 (8.9%) Chestnut-sided Warbler, 91(8.2%) Bay-breasted Warbler, 91 (8.2%) Red-eyed Vireo	64
ON, CAN	1962	3446	66	Thrush, Warbler, Vireo	65
ON, CAN	1963	1190	71	Thrush, Warbler, Vireo	66
Orion, IL, USA	1959	88		Swainson's Thrush, Warbler	505
Philadelphia, USA	1948			Warbler	603
S. Atlantic coast, USA	1954			Ovenbird, Red-eyed Vireo	156
S. Erie County, NY, USA	1967-71	4094	82	450 (11%) Ovenbird, 409 (10%) Golden Crowned Kinglet, 287 (7%) Blackpoll Warbler, 287 (7%) Gray-cheeked Thrush, 246 (6%) Vireo	167
South Bend IN, USA	1959	49		Swainson's Thrush, Warbler	505
Topeka Tower, KS, USA	1967	**800**	43	240 (30%) Nashville Warbler	152
Topeka, KS, USA	1955	16	2	15 (94%) Mourning Warbler, 1 (6%) Connecticut Warbler	83

Various		16118		2498 (15.5%) Ovenbird, 1950 (12.1%) Tennessee Warbler, 1418 (8.8%) Red-eyed Vireo, 1418 (8.8%) Magnolia Warbler	259
Vero Beach, USA	1970	31		Warbler	633
WBAL-TV, Baltimore, MD, USA	1970	1965	43	489 (25%) Ovenbird, 410 (21%) Red-eyed Vireo	671
WBAL-TV, Baltimore, MD, USA	1973	180		Warbler	673
WBAL-TV, Baltimore, MD, USA	1970	1800	41	435 (24%) Ovenbird, 391 (22%) Red-eyed Vireo, 148 (8%) Black and White Warbler, 115 (6%) Common Yellowthroat, 81 (5%) Magnolia Warbler	
WBAL-TV, Baltimore, MD, USA	1964-66	3595	74	899 (25%) Ovenbird, 468 (13%) Black-and-white Warbler, 395 (11%) Magnolia Warbler	136
WBDO-TV, Orlando, FL, USA	1970	2790	51	Warbler	633
WCIX-TV, Homestead, USA	1970	**300**		Warbler	633
WCSH-TV, Sebago, USA	1973	**300**		Warbler, Thrush	292
WCTU-TV,Tallahassee, USA	1962	249		Red-eyed Vireo	578
WCTV-TV, Leon County, FL, USA	1963	735		81 (11%) Bobolink	191
WCTV-TV, Leon County, FL, USA	1964	709		335 (47%) Yellow-rumped Warbler	713
WCTV-TV, Leon County, FL, USA	1973-75	3864	109	896 (23%) Red-eyed Vireo, 219 (6%) Ovenbird, 159 (4%) Common Yellowthroat, 140 (4%) Magnolia Warbler	899
WCTV-TV, Tallahassee, USA	1960	237	53	Warbler	633
WCTV-TV, Tallahassee, USA	1960	384		230 (60%) Sparrow	637
WEAU-TV, Eau Clair, WI, USA	1968	145		Kinglet, Warbler	629
WECT & WWAY-TV, SE NC, USA	1971-77	7270		1023 (14%) Common Yellowthroat, 925 (13%) American Redstart, 865 (12%) Ovenbird, 701 (10%) Red-eyed Vireo, 549 (8%) Black-and-white Warbler	888
WECT-TV, NC, USA	1971-72	3070	84	Warbler, Sparrow, Thrush, Vireo, 583 (19%) Common Yellowthroat, 288 (9.4%) Black-throated Blue Warbler, 267 (8.7%) Ovenbird, 218 (7.1%) Yellow-rumped Warbler, 163 (5.3%) Gray Catbird	Chat (1976) 140(1)
WEHN-TV, Deerfield, NH, USA	1959	130		74 (57%) Ruby-crowned Kinglet	661
West Brands, IA, USA	1970	58	16	Kinglet, 14 (24%) Nashville Warbler, 9 (16%) Ruby-crowned Kinglet, 8 (14%) Yellow-rumped Warbler, 7 (12%) Golden-crowned Kinglet	1022
WFMJ-TV, Youngstown, OH, USA	1975	1057	39	Warbler, 317 (30%) Ovenbird	78
WFMS-TV, Youngstown, OH, USA	1977	315		Bay-breasted Warbler, Blackpoll Warbler	873
WHEN-TV, Syracuse, NY, USA	1959	45		Thrush, Vireo, Warbler	662
WHIO-TV, Dayton, OH, USA	1967	348	45	Red-eyed Vireo, Warbler	591
WHNT-TV, Huntsville, USA	1976	42	18	27 (64%) Warbler	896
WIS-TV, Columbia, SC, USA	1969	**500**	20	Warbler, Thrush, Vireo, Common Yellowthroat, Magnolia Warbler	165
WJBF-TV, Aiken, SC, USA	1962	200	32	48 (24%) Swainson's Thrush	Chat (1963), Mar
WJBF-TV, Aiken, SC, USA	1962	400	32	239 (60%) Red-eyed Vireo	601
WMC-TV, Memphis, TN, USA	1961	19	11	Warbler, Vireo	176
WMC-TV, Memphis, TN, USA	1964	99	21	58 (58%) Red-eyed Vireo	176
WPSK-TV, Clearfield Co. PA, USA	1969	75		Brown Creeper, Kinglet, Warbler	1039

WSM & WNGE-TV, Nashville TN, USA	1976	406	43	63 (16%) Ovenbird, 61 (15%) Tennessee Warbler, Magnolia Warbler, Bay-breasted Warbler	920
WSM & WSIX-TV, Nashville TN, USA	1971	3560		Warbler, 845 (24%) Tennessee Warbler, 631 (18%) Ovenbird, 429 (12%) Black-and-white Warbler, 420 (12%) Magnolia Warbler	452
WSM-TV, Nashville TN, USA	1967	160	12	115 (72%) Blackpoll Warbler	448
WSM-TV, Nashville TN, USA	1968	5408		4380 (81%) Warbler	450
WSYE-TV, Elmira, NY, USA	1963	200	36	Warbler	342
WSYE-TV, Elmira, NY, USA	1968	260	30	Warbler	346
WSYE-TV, Elmira, NY, USA	1973	465	39	Warbler	351
WSYE-TV, Elmira, NY, USA	1974	844		246 (29%) Bay-breasted Warbler	352
WSYE-TV, Elmira, NY, USA	1977	3874	48	1227 (32%) Bay-breasted Warbler, Magnolia Warbler, 311 (8%)Ovenbird, 218 (6%) Swainson's Thrush	353
Youngstown, OH, USA	1975	1050		305 (29%) Ovenbird	27

Bold indicates where number given is an estimate or a minimum

**Numbered references refer to Avery, M.L., P.F. Springer, and N.S. Dailey (1980). Avian mortality at man-made structures: An annotated bibliography (revised). U.S. Fish and Wildlife Service, Biological Services Program, National Power Plant Team, FWS/OBS-80/54. 152pp.*